Sound Levels from Headphone/Portable Compact Disc Player Systems

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Introduction

Concerns have arisen over the potential for noise induced hearing loss in users of personal cassette and portable compact disc players. The results of several studies in other countries [1-3] suggested that, of the children and young adults using personal cassette players, approximately 10 - 15% received exposures exceeding the Canadian Federal occupational noise exposure limit. Compared to cassette tape recordings, compact discs can provide a wider dynamic range and higher quality sound at loud levels. As a result, the recent growth in the popularity of portable compact disc (CD) players has added to the concerns about noise exposure.

Different approaches can be taken to manage the risk of noise induced hearing loss from use of both types of players. For example, France has recently adopted legislation limiting the acoustic output of these devices to 100 decibels A-weighted (dB(A)). To help examine options for Canada, sound level measurements were made on a variety of headphone/portable CD player combinations. This paper presents the findings of that measurement survey.

The results are discussed with regard to the risk of noise induced hearing loss from prolonged use at maximum volume settings.

Method and Apparatus

The maximum sound levels were measured from combinations of eight recent model portable compact disc (CD) players and 18 headphones sold in Canada. The eight CD players were identified as CD1. . . CD8. Only two of these eight models were from the same manufacturer (CD2 and CD8).

Sound levels were measured for 24 combinations of the headphones and CD players. Eight combinations consisted of the CD player and headphone with which it was packaged at purchase. Ten additional combinations were obtained using separately purchased headphones with CD1. This player was used to assess the relative sensitivities of these headphones because its output power varied by less than 0.8 dB over the range of headphone impedances (16 to 32 ohms). The most sensitive of these 10 headphones, identified as P6, was also combined with CD3 to CD8.

Most of the CD players were supplied with supra-aural headphones with porous ear pads. The exceptions were CD1 and CD5. These were provided with intra-concha headphones, which had no headband. Instead, the earpiece fit into the concha, with the diaphragm facing the ear canal.

Seven of the 10 additional headphone models studied were intra-concha and one was supra-aural with a porous ear pad. For the other two models, the earpiece fit into the concha and resembled that of the intra-concha headphone. However, the earpieces were mounted on a headband with the diaphragm facing forwards, instead of into the ear canal. The diaphragm orientation prevented this other type of headphone from making a seal around the ear canal.

Two recorded sounds were measured: (i)a "heavy metal" CD music track (Mackaye et al., "Filler/I don't want to hear it" in: "Undisputed Attitude," Slayer, American CDW 43072) and (ii)a filtered pink noise track conforming to the IEC requirements for a simulated programme signal [4], with a 13 dB crest factor and the peak recorded at the maximum level on the CD. The durations of the two tracks were 148 and 128 seconds, respectively.

Measurements were made at the internal microphone of a Bruel & Kjaer type 4128 Head and Torso Simulator (HATS) using a Hewlett Packard 35670A analyser to provide real time 1/12 octave band sound pressure levels. For each measurement, the CD player's volume control was set to maximum and the player's "bass boost" was switched on. The data was obtained by starting the CD player, allowing 7 seconds for the analyser filters to settle and averaging over 135 and 64 seconds for the "heavy metal" and IEC tracks, respectively. Before and after each set of measurements, the internal microphone sensitivity of the HATS was checked at 1 kHz using a Bruel & Kjaer type 4230 piezo calibrator. During all tests, the output from the HATS was monitored by an external speaker to ensure acceptable operation of the headphones. The background noise level was at least 30 dB(A) lower than the measurements.

For measurements, headbands were positioned vertically on the HATS. The earpiece was aligned visually on the HATS's anatomically realistic pinna for optimum coverage of the ear canal and cavum. For the intra-concha headphones, the tragus was pulled forward and then the headphone was inserted in the cavum. After the initial fitting, the headphones were checked for a secure fit, and realigned if necessary.

The sound levels of interest were the A-weighted, equivalent continuous sound pressure levels (Leq) in the absence of a subject, that would produce the sound pressure levels measured at the HATS's internal microphone. To obtain the Leq values, the appropriate frequency response of the HATS, as supplied by the manufacturer, was subtracted from the measured 1/12 octave band data to yield the sound pressure levels in a diffuse field. The A-weighting was then applied and the band levels summed. Values for Leq were also calculated for sound incident normal to the forehead. For all but one combination, it was found that the difference from the corresponding diffuse field level was less than 1 dB. The reproducibility of the Leq values was estimated as ±5 dB for intra-concha headphones and ±2 dB for the two other types.

Results and Discussion

The results in Table 1 showed that, for "heavy metal" music, a number of headphone/CD player combinations could create exposures exceeding the Canadian Federal occupational noise limit. For all the systems that were tested as sold, the measured short duration Leq values for the "heavy metal" track ranged from 90 dB(A) to 105 dB(A). The occupational noise limit was an equivalent continuous sound pressure level of 87 dB(A) for 8 hours per day, with a 3 dB(A) exchange rate [5]. Therefore, the daily listening durations needed to exceed the occupational noise limit varied from about 8 minutes to 4 hours. Five of the eight systems required daily listening times of no more than 1 hour. For

the most sensitive headphone, P6, using the IEC signal, the limit was exceeded for listening times ranging from 45 seconds to about 40 minutes for the various CD players. Similar results could be inferred for the "heavy metal" track because of the similarities in the Leq values when the original headphones were used with both recordings.

The listening times required to exceed the occupational noise limit were within the ranges found in surveys of listening habits of users of personal cassette players [1-3, 6]. In those studies, typical listening times ranged from about 30 to 90 minutes per day, but a few percent of the population surveyed listened as much as 4 hours per day.

To assess the potential health impact further, an estimate was also made of the predicted permanent noise induced hearing loss [7] if users listened to the sound levels in Table 1 for 1 hour per day for 5 years, the estimated typical exposure duration [1-3,6]. Calculations were made of the noise induced permanent threshold shifts, averaged over the pure tone (speech) frequencies of 500, 1000, 2000 and 3000 Hz for the 5% most susceptible ears in a screened population of 18 year olds. This pure-tone-average is often used in the evaluation of hearing impairment for compensation purposes [8]. The calculated hearing losses ranged from 0 to 13 dB for the original headphone combinations. Use of the most sensitive headphone, P6, increased the calculated hearing loss to between 4 and 39 dB.

The results presented in Table 1 also showed a wide range in Leq values, 28 dB, depending on the headphone/portable CD player combination. This large range was due to the differences in headphone sensitivity and the different maximum output powers of the CD players. For example, the headphone sensitivity changes 17 dB when the original headphone for CD6 is replaced by P6. The effect of the CD player output is shown in the last line of Table 1, the Leq varies by 17 dB when the same headphone, P6, was used on each unit.

In addition, the results showed that intra-concha headphones tended to have a higher sensitivity than the other two types of headphones. For the measurements on CD1, with the ten separately purchased headphones, the seven intra-concha headphones yielded Leq values between 102 and 108 dB(A). By contrast, the other two types only produced 92 to 96 dB(A). Comparison of the first and third rows of Table 1 also supports this conclusion. The intra-concha headphone P6 was 11-17 dB more sensitive than all but one of the supra-aural headphones originally supplied with the CD players. By contrast, P6 was only 2-6 dB more sensitive than the intra-concha headphones supplied with CD1 and CD5.

Although detailed comparisons were not possible, the largest values found in other studies of maximum sound levels from portable CD and personal cassette players [2-3, 9] were within the broad range of values found in this study.

Conclusions

The information provided in this work on the potential for noise induced hearing loss can be used to warn of the consequences of prolonged listening to "heavy metal" music through headphones at maximum volume settings.

For this type of music, all the headphone/CD player combinations packaged together at purchase could provide exposures exceeding Canadian Federal occupational noise exposure limits. However, for typical exposure durations, even if all users listened at maximum volume settings, estimated noise-induced hearing losses varied strongly, from 0 - 13 dB. These variations were greatly increased, from 0 - 39 dB, when separately purchased headphones were combined with the CD players.

Potential hearing losses depended significantly on both the headphone and the CD player. In particular, for a given CD player, there was a tendency for sound levels to be significantly greater if intra-concha headphones were used. This suggests that the extent to which headphones are purchased separately may be an important consideration in evaluating options for reducing the risk of noise-induced hearing loss from use of these devices.

References

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TABLE 1. Equivalent continuous, diffuse field, A-weighted sound pressure level, short duration Leq, obtained using the IEC simulated programme signal and the "heavy metal" track. The eight CD players were combined with either the original headphones which accompanied them at purchase or with P6, the most sensitive headphone purchased separately.

Signal	Head phone	Portable CD Player							
		CD1	CD2	CD3	CD4	CD5	CD6	CD7	CD8
IEC	Orig.	102	98	99	91	102	87	87	93
Metal	Orig.	105	101	101	94	100	90	90	96
IEC	P6	108	-	115	104	104	104	98	98